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This paper outlines work of the authors in support of the Unit Manning initiative directed by the Secretary of the Army. In this work manning concepts are explained and analyzed, Unit Manning concepts are developed, and a scheduling model that was utilized to analyze the effect of Unit Manning on the Army as a whole is discussed. The heuristic model is rules based and calculates a Unit Manning and Unit Rotation Schedule of the Army's 33 Brigade Combat Teams. The model conducts two passes over the time horizon, first calculating a rotation schedule and then overlaying a unit manning schedule on those rotations. The rules are adjustable by fourteen inputs, thus allowing the user to determine the effects of policies throughout the 160-month planning horizon. Output of the model consists of a Manning and Rotation schedule that additionally supports analysis of transformation decisions, and identification of friction points in terms of unit availability and personnel requirements.

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Abstract

This paper outlines work of the authors in support of the Unit Manning initiative directed by the Secretary of the Army. In this work manning concepts are explained and analyzed, Unit Manning concepts are developed, and a scheduling model that was utilized to analyze the effect of Unit Manning on the Army as a whole is discussed. The heuristic model is rules based and calculates a Unit Manning and Unit Rotation Schedule of the Army's 33 Brigade Combat Teams. The model conducts two passes over the time horizon, first calculating a rotation schedule and then overlaying a unit manning schedule on those rotations. The rules are adjustable by fourteen inputs, thus allowing the user to determine the effects of policies throughout the 164-month planning horizon. Output of the model consists of a Manning and Rotation schedule that additionally supports analysis of transformation decisions, and identification of friction points in terms of unit availability and personnel requirements.

1. Introduction

In the summer of 2003, the authorized strength of the all-volunteer active Army stood at approximately 480,000 soldiers. Of these, nearly 305,000 were assigned to combat, support and service support units. In an organization as large as the Army, personnel losses occur daily across all ranks and skills. Replacements must be recruited and trained year-round to cover losses. After initial entry training, the Army provides soldiers of all ranks with professionally developing opportunities. These include formal in-class training for specific skills, professional military education and on-the-job training. The full spectrum of experiences are designed to make soldiers competitive for promotion and to serve in positions of increasing responsibility for a full career lasting 20 years or longer.

World War I generated a level of demand for soldiers with basic combat skills not seen since the Civil War. At the beginning of World War I, the Army needed large numbers of soldiers quickly to build new combat units. Later, soldiers were needed to replace battlefield casualties in committed units. The Army responded to meet demand by (1) implementing a large-scale basic combat training program; and (2) adopting an individual replacement system for assigning soldiers to duty positions throughout the Army. This initial entry training program was similar in certain respects to mass production methods of the time. Professional, combat-

experienced cadre (when available) taught draftees basic combat and survival skills at military installations. Following initial entry training, soldiers flowed through the personnel pipeline to new units or to units already committed in a theater of operations.

For over eight decades, during both peace and war, the individual replacement system has provided the Army with an efficient, flexible means to simultaneously man Army units and meet the professional development needs of individual soldiers. This system, evolving and improving over time, served the Army well in World War II, Korea, Vietnam, Desert Storm and today in Operation Iraqi Freedom.

The U.S. Army Human Resources Command (HRC), formerly known as U.S. Army Personnel Command (PERSCOM), located in Alexandria, Virginia, oversees the individual replacement system. Staffed with hundreds of officers, warrant officers, noncommissioned officers and civilian personnel, HRC manages unit gains and losses, soldier assignments, professional development and career progression in accordance with regulations, policies, and laws governing such actions. HRC intensely manages soldier career development at the individual level. HRC personnel managers attempt to balance needs of the Army with the assignment preferences of individual soldiers which are often influenced by concerns for family well-being and stability. HRC also ensures that assignments provide soldiers with professional development opportunities so they remain competitive for promotion. In addition to filling operational requirements in operational Army units, HRC also staffs a wide range of institutional organizations. These include faculty and students assigned to military and civilian schools such as West Point and ROTC, recruiting duty, active component/reserve component (AC/RC) advisor positions, and non-tactical positions in major commands (MACOM) and major subordinate commands (MSC). The bottom line: HRC ensures that the 'right' soldiers are assigned to jobs enabling the Army to accomplish missions while carefully managing soldier's developmental opportunities in their pursuit of a successful career.

Under the individual replacement system, soldiers move in and out of units throughout the year. Assignments normally last three years but often vary between 12 to 48 months. Military units and institutional organizations manned with soldiers assigned for three year tours experience approximately one-third unit turnover per year. When assigned to a duty station for three years, it is common for soldiers to change jobs several times before moving to another duty station. Transfers and promotions create upward and lateral opportunities that present important developmental opportunities for junior soldiers to demonstrate capabilities essential to career advancement.

The notable exception to the three year assignment is the short tour where soldiers are assigned to remote locations without dependents for one year. Replacing personnel losses in short tour units has become one of HRC's toughest challenges. Short tours impact the entire Army personnel assignment system. They drive up unit turbulence which hurts readiness and significantly increase travel and related costs to move soldiers and families. Units manned by short tours experience nearly 100% annual turnover; two to three times higher than units manned with three-year tours. The majority of Army short tours support the 2nd Infantry Division in South Korea. It has been estimated that maintaining the 22,000 soldiers assigned to South Korea drives 30 to 40 percent of all Army turbulence [United States Military Academy, 2002]. Three-year stateside assignments are routinely cut short to meet overseas short tour requirements. In some respects, the rest of the Army serves as a pool of personnel for meeting Army-wide short tour replacements.

Despite the benefits of the individual replacement system, Army leaders have long recognized that unit turbulence generated by frequent personnel turnover breaks down unit cohesion and reduces readiness in combat units where high cohesion and teamwork are critical to success [Naylor, 2002]. In August 2002, the Army undertook a study to analyze the feasibility of changing how the Army assigns soldiers to combat brigade teams; from the individual replacement system of today to a unit manning system (UMS). Under unit manning, the arrival, collective unit training, and departure of most personnel assigned to combat brigade teams will be synchronized with the unit's mission. The objective is to set conditions for unit leaders, and the Army, to build higher performing combat teams. By enabling soldiers to train together as a team, and serve together for extended periods of time, the Army will enhance cohesion and teamwork in combat brigades thereby enabling the units to more effectively and efficiently accomplish assigned missions.

This report documents development of a unit manning scheduling model by the authors that was subsequently used to (1) analyze the feasibility of unit manning the Army's combat brigades; and (2) identify and analyze Army-level 'friction points' related to transitioning from an individual replacement system to a unit manning system. Sections 2 and 3 discuss unit manning concepts and methods, respectively. Section 4 presents the unit manning scheduling model. Section 5 gives model results briefed to senior Army leaders leading to decisions to unit man the Army. Section 6 recommends policy changes and outlines the way ahead for unit manning implementation.

2. Unit Manning Concepts

In August 2002, the Army Deputy Chief of Staff for Personnel (Deputy G1), Major General Larry Adair, organized an ad-hoc group to study personnel turnover and turbulence in Army units and recommend solutions. Members of the ad-hoc working group included Colonel Bob Shaffer (G1), Colonel Mike McGinnis (Department of Systems Engineering, U.S. Military Academy), Lieutenant Colonel Karl Reed (G1) and LTC Paul Thornton (G1) among others. After studying and discussing the problem, the group concluded that unit manning was a feasible alternative to reducing turbulence in the Army. The Task Force recommended a full time task force be created to further develop unit manning alternatives, formulate an implementation plan and recommend changes to personnel policies to make them supportive of unit manning.

On October 18, 2002, Army Vice Chief of Staff, General Jack Keene, formally chartered a Unit Manning Task Force to accomplish the following:

- Review the history of Army unit manning, and related efforts, and draw lessons from these efforts.
- Define, scope and bound the unit manning problem.
- Recommend alternatives for unit manning the Army to enhance unit cohesion and improve Army readiness.
- Analyze costs and policy implications of implementing a unit manning system.
- Recommend an implementation plan to transition from an individual replacement system to a unit manning system.

2.1 Historical Overview of Unit Manning

Historical records document over a dozen attempts by the Army to unit man combat organizations since the mid-1900s. In each case, the Army eventually reverted back to an individual replacement system. Table 2.1 below cites, and briefly summarizes, major unit manning initiatives since 1955 [Thurman, 1989]. Past unit manning initiatives provided an understanding why previous attempts failed. The Task Force also gained an appreciation for the complexity of and key insights into unit manning large Army organizations. Key lessons learned are given below.

- Unit manning achieved horizontal bonding among enlisted soldiers but commissioned and noncommissioned officer turnover broke down vertical cohesion. Senior leaders were allowed to depart units for personal and professional reasons but junior enlisted soldiers were locked-in for the duration of the unit manning cycle. Leader turnover created resentment and frustration among lower ranks.
- Unit leaders were not prepared for the challenges of sustaining unit cohesion and high unit performance once the unit reached acceptable standards of training readiness.
- Senior Army leaders failed to think through and plan Army-wide unit manning. In support of the transition from individual to unit manning, the Army failed to change personnel management policies and processes and failed to change soldier professional development for training, military schools and promotion policies.
- Several unit manning initiatives were overcome by world events while others lost momentum by not synchronizing unit manning with on-going Army initiatives.
- Piecemeal implementation of unit manning, in terms of time and location, created disparity and friction between unit manned units (haves) and IRS manned units (have nots).

HISTORICAL SUMMARY OF UNIT MANNING INITIATIVES				
Title	Description	Reason for Failure	Remarks	Source
Gyroscope (1955-1959) EUROPE	Rotation of entire divisions, regiments, and battalions (with family members) from stateside to FRG.	Expected results not realized, increased cost flow, combat effectiveness fluctuation too large across 3 phases (initial, mid-tour, end). Administrative burden and resource costs were high during time of major budget reductions	Most ambitious unit manning ever attempted. Morale increased, delta in effectiveness documented across 3 phases. Importance of unit cohesion as a combat multiplier learned by future leaders Thurman, Wagner and Foss	Trefry/ Elton
OVUREP (1961-1962) KOREA	Rotation of combat units (without family members) to Korea for one year timeframes	Berlin Crisis ('62) - could not handle contingencies. Test program rushed without implementation of plans and policies needed for success. Focus was on rotation - not cohesion.	7 Brigade Groups deployed, all expectations met, draft supported, 12 month tour, "combat zone". Extremely successful compared to individual replacements. Departure from Gyroscope - no family members moved and units were smaller. Achieved degree of cohesion and bonding despite policies	Trefry/ Elton
Long Thrust (1962-1963) EUROPE	Test of strategic mobility (3 Bdes) to Europe - 3 month TDY, no family members	Increased costs, reduced readiness of units	Completed 7 exercises	Trefry
ROTAPLAN (1962-1963) EUROPE	Rotation of battle groups from CONUS to Europe, without dependents, for a six month tour	Personnel turbulence, decreased readiness, did not achieve reduced B-P deficits actually increased and increased costs. Test program rushed without implementation of plans and policies needed for success. Focus was on rotation - not cohesion.	Congress directed, no dependents, 3 Brigade Group per rotation (2Yr) 1-Berlin, 1-trng, 1-CONUS. Achieved degree of cohesion and bonding despite policies	Trefry/ Elton
UN rotation plan (1974) Brigade 75-76	Exercise AF - Army joint mobility & POMCUS; show support for NATO, tie US Div to Europe	Increased cost, decreased Europe total readiness, MACOM pressure	FORSCOM, Europe, CSA against it, Approved by SECDEF after CSA death (1974). 1 example reassigned 3081 EM to deploy 2742 in Bde	Trefry
Cohesive Unit Program (CUP) 1982	Platoon level program started by GEN Shoemaker at FORSCOM.		CUP proved successful - easily handled by all Theaters and by FORSCOM - Led to Company COHORT; if platoons were good, then companies and battalions must be better	Elton
Regimental Concept (1982)	Career long affiliation recurring battalion level assignments CONUS & OCONUS	Never fully implemented or evaluated		Thurman
Company Replacement Model (18/18) (Project COHORT) (1981) EUROPE	Unit formed in FORSCOM, trained for 18 months then group moved to Europe with families for 18 months then disestablished	Unsupportable in USAREUR as cycles for individual tour length and OCONUS life cycle did not coincide, local installations could not absorb residual soldiers, higher intra-CONUS turbulence	Terminated due to unsupportable	Thurman
Company Replacement Model (24/12) (Project COHORT) KOREA	Unit formed in WESTCOM or FORSCOM for 24 months then deploys to Korea for 12	Sustainable, but EUSA, FORSCOM and WESTCOM all expressed different reservations.		Thurman
Battalion Rotation Model (36/36) (1984-1986)	Units are linked in CONUS-OCONUS pairs on same cycle. Each unit spends 3 yrs in MACOM and rotates at mid-point in unit's tour	Field evaluation and chain of command indicated model unacceptable to USAREUR as local installations and communities could not accept impacts of rotating battalions		Thurman
Traditional Non-deploying Battalion Model (36mo)	Unit has fixed 3 yr cycle with soldiers and leaders stabilized for full time. Annual "top off" for unprogrammed attrition. Unit forms, trains, disestablishes at same location	Total of 27 battalions established on this model (18 activated, 9 converted) to facilitate change of infantry forces to ID(L) design	COHORT concept seems to operate most effectively when entire division is COHORT. Not fully evaluated	Thurman
Sustained COHORT Model (PRS4) 1986	Similar to non-deploying model with a continuous lifecycle in which assignment windows every 4 months, everyone only stabilized between windows	Implemented in 1986 following termination of Battalion Rotation Model - 141 companies on this model with 177 projected at time of report. Not evaluated or analyzed	WRAIR assessment is that 4 month stability will not provide enhanced cohesion	Thurman
Sustained COHORT Model (PRS12)	Similar to non-deploying model with a continuous lifecycle in which assignment windows every 12 months, everyone stabilized between windows	Not intended for fielding, was applied to the 7th and 10th ID(L) as a compromise. Currently 60 companies on the model and 88 projected at time of report. Not evaluated or analyzed	12 month stability is minimum acceptable to WRAIR to provide enhanced cohesion	Thurman

Table 2.1 Overview of Unit Manning Initiatives

2.2 Problem Definition

Operational successes of the U.S. Army dating back to World War I can be traced to the important contributions the individual replacement system made to manning and sustaining combat units. For decades, IRS manned units successfully accomplished missions ranging from combat to peacekeeping to humanitarian relief. Today, the individual replacement system continues to provide the Army with a flexible means for manning all types of units to meet all missions.

By design and implementation, the individual replacement system is highly individual centric. Constant personnel turnover generates significant unit turbulence that breaks down cohesion. Factors that degrade unit cohesion and readiness are listed below.

- The steady flow of personnel in and out of combat units breaks down bonds between soldiers and disrupts unit cohesion and teamwork. This is especially troublesome in combat and combat support units where cohesion and teamwork are needed most.
- Constant personnel turnover leads to wide varying degrees of experience among soldiers. Most turn-over involves lower-skill level soldiers. This requires units repeatedly train on basic skills and lower echelon training preventing progression to higher level and higher echelon training. Turnover impedes the unit from functioning together as an integrated team for any extended period of time.
- Close to 100% yearly turnover in short tour units makes cohesion difficult, if not impossible to achieve.
- Manning short tour units requires personnel managers to cut short three year stabilized tours which disrupts soldier stability and military family well being. It also drives up costs as soldiers often move families before the short tour and, twelve months later, the families move to the next duty station.
- The individual replacement system is not well suited to synchronizing assignments of soldiers to align with the unit's mission which is important to setting conditions for success.

What is the Nature of Future Military Operations?

Since the Cold War ended, the Army operations in Panama, Haiti, Somalia, Desert Storm, Kosovo, Bosnia, Operation Enduring Freedom (OEF) in Afghanistan and Operation Iraqi Freedom (OIF) have been the full spectrum: Combat, peacemaking, peacekeeping and humanitarian support. Future operations will be full spectrum, day and night, chaotic, rapid, intense, lethal, fluid, decentralized, come-as-you-are with little or no notice taking place in complex urban environments and remote, rough terrain. Distinguishing neutral actors from hostile enemy forces will be difficult at best. These conditions will generate high levels of stress, fear, uncertainty and fatigue and have the potential to quickly break down weak teams into self-serving groups of individuals more concerned with personal safety and survival than mission accomplishment.

What is Unit Manning?

The intent of unit manning is to set conditions for unit leaders, and the Army, to build cohesive, high performing combat teams by rigorously managing personnel turnover to reduce unit turbulence and stabilize combat units. Reducing turnover commonly experienced in IRS manned units will set conditions for soldier bonding and foster unit cohesion; both of which are critical for combat teams to accomplish missions. Over time, increased unit stability will also improve the predictability of Army life for soldiers and enhance well being for Army families.

What Units should be Unit Manned?

Scoping and bounding the unit manning problem led the Task Force to examine various military organizations to determine which units need to be unit manned and, of those, which were most suitable. Screening criteria for identifying unit-manned units, necessary and sufficiency conditions, included echelon (company, battalion, brigade, division, corps), unit type (combat, combat support, combat service support), density of soldier skills, unit geographic location, mission essential task list (METL) and range of assigned missions.

Based on analysis and assessments, along with feedback from stakeholders and experts, the Task Force concluded it was neither practical, necessary, nor feasible to unit-man all Army units. Units which must either remain continuously functional or be continuously ready for a crisis are not good candidates. Accordingly, we bounded unit manning to where it was needed most and to units that would benefit most; namely, combat and combat support units at brigade and below.

Linking Unit Manning to Strategic Army Initiatives

Lessons learned from past initiatives suggested it was important to synchronize unit manning with on-going strategic Army initiatives would help facilitate successful implementation of unit manning by leveraging momentum of on-going initiatives. Two on-going strategic Army initiatives that make this 'the right time' for unit manning are Army transformation and unit rotations.

Unit Manning in Support of Army Transformation.

The Army is presently transforming separate armor, infantry, and cavalry brigades into six Stryker brigade combat teams (SBCT) and, following that, Units of Action (UAs). Key features of Stryker brigade teams and Units of Action include:

- organized as fully functional combat teams;
- downsized from approximately 5000 soldiers today to approximately 3800 and 2600 soldiers in SBCTs and UAs, respectively;
- more technologically advanced than brigades today;
- deployable world-wide within 96 hours compared to two to six weeks today; and
- self-sustainable combat team for short periods of time.

Stryker transformation started in 2000 and will continue through 2007. Currently, the first Unit of Action is scheduled to transform starting in 2008. Along with organization,

technology and equipment changes, fielding the new units will require major changes to doctrine, tactics, techniques and operating procedures. Transformation is accomplished in several phases: Equipment turn-in, unit set fielding (USF), new equipment training (NET), collective training, major readiness exercises to assess initial operational capability (IOC) and final operational capability (FOC), and culminating with unit certification. Once old equipment is turned in, the unit is 'stood down' for the transformation period generally lasting 12 to 36 months. Once certified, the unit is declared 'ready' for military operations [Berry, 2002].

Under IRS, the Army normally stabilizes transforming units using a practice called fencing. Fencing a unit stabilizes soldiers for the transformation period from unit set fielding through initial operational capability. IOC is a major training event designed to assess the progress of the unit under realistic, controlled conditions. Although stabilization rules vary by type of unit, mission, or location, the objective is to enable the unit to accomplish the mission. Personnel usually remain in the same duty position until IOC which prevents soldiers from attending military schools or being reassigned unless released early by the chain of command.

The first Stryker brigade combat team (SBCT1), 3rd Brigade of 2nd Infantry Division, experienced significant unit turbulence due to poorly coordinated fencing. By the second year of a three-year transformation, the unit experienced 62% personnel turnover [Berry, 2002]. This resulted in numerous unplanned, un-resourced repeats of new equipment training. It also delayed collective training which had to be repeated as well. By IOC in May 2003, 65% of the key leaders, including all maneuver commanders, were scheduled to depart the unit within a month after IOC which broke down cohesion and degraded readiness (see Table 2.2 below). Under unit manning, personnel assignments will be synchronized with the unit's lifecycle from unit set fielding through post-transformation employment, assuming transformation and post-transformation employment can be accomplished in 36 months.

Brigade (BDE)	Arrival Date	Planned Departure
Commander (CDR)	JUL 2002	JUL 2004
Command Sergeant Major (CSM)	MAY 2000	JAN 2003
Executive Officer (XO)	AUG 2002	JUN 2003
Personnel (S1)	JUN 2002	JUN 2003
Intelligence (S2)	JAN 2003	JUN 2004
Assistant Intelligence Officer (A/S2)	JUN 2002	JUN 2003
Operations (S3)	JUN 2002	JUN 2003
Logistics (S4)	MAY 2001	JAN 2003
Psychological Operations (S5)	JUN 2001	JUN 2003
Communications and Electronics (S6)	DEC 2002	DEC 2003
Civil Affairs (S7)	JUN 2001	JUN 2003
DECOORD	JUN 2002	JUN 2003
Military Police (MP)	JUN 2002	JUN 2003
Engineer (EN)	JUN 2002	JUN 2003
Battalion (BN)		
Commander, 2-3 Infantry (IN)	MAR 2001	JUN 2003
Commander, 5-20 Infantry (IN)	JUN 2001	JUN 2003
Commander, 1-23 Infantry (IN)	JUN 2001	JUN 2003
Commander, 1-14 Cavalry (CAV)	JUN 2001	JUN 2003
Commander, 1-37 Field Artillery (FA)	JUN 2002	JUN 2004
Commander, 296 BDE Support BN (BSB)	JUN 2002	JUN 2004

Table 2.2. Leader Turnover for Stryker Brigade Combat Team One (SBCT1), Fort Lewis

Unit Manning in Support of Unit Rotations.

The end of the Cold War brought changes to the international landscape that caused the Department of Defense to rethink how to respond to world crises. Across all services, military troop strengths and forces were reduced by approximately 45% resulting in numerous military bases closures. A five fold increase in deployments in the 1990s, compared with the Cold War Era, hastened Army efforts to transform from a heavy, forward deployed force to a quick-reaction expeditionary force [Berry, 2002]. Short tours continue to sustain Korea, but it has been 6-to-12 month unit rotations that met demands of increased operational tempo.

As with transformation, rotational units are also fenced under IRS. Non-deployable personnel are transferred to other units in exchange for deployable replacements three to six months prior to the rotation. This gives the rotating unit time to integrate and train new personnel. However, the practice of transferring non-deployable personnel conceivably increases non-deployable personnel to between 50 to 80% of assigned strength. Rotational units generally experience substantial turnover among fenced personnel who become transfer eligible following the rotation.

To mitigate hardships that rotations impose on soldiers and families, the Army adopted policies to stabilize soldiers for six months following a short tour or rotation. Soldiers are exempted from a rotation if it impacts (1) a scheduled change of station; (2) professional schooling; or (3) extends past a soldier's termination of military service date. A recent RAND study of Bosnia deployments reveals approximately 38% of personnel assigned to rotating units were not deployable under peacetime policies and rules (see Table 2.3 below). IRS-related fencing practices significantly contribute to personnel turnover, unit turbulence and degrade unit readiness in rotational units.

SOLDIER NON-DEPLOYABILITY UNDER PEACETIME RULES	PERCENT OF SOLDIERS NON- DEPLOYABLE BY UNIT / INSTALLATION		
	1st CAV	10 th MTN	Fort Riley
Wartime non-deployable soldiers	4.0%	3.9%	3.5%
Windows for PCS (45 days), ETS (90 day), and Command Loss (135 day)	20.0%	16.9%	21.8%
Stabilization policy for soldiers returning from short tour or rotation	11.6%	18.6%	14.7%
TOTAL	35.6%	39.4%	40.0%

Table 2.3. Reasons soldiers non-deployable for three recent Bosnia rotations

Unit manning will synchronize assignments of soldiers to rotating units ahead of time to build a stabilized unit for the duration of the rotation and beyond. This stabilized period would also include time for leaders to train the unit prior to the deployment. By significantly reducing the percentage of non-deployable personnel under peacetime deployment rules, unit manning will greatly simplify the process for preparing units to rotate.

3. Unit Manning Methods

Unit manning is about building teams. The system presented here for manning units consists of three methods engineered and designed specifically for tactical combat units at brigade and below. However, the methods can be applied just as well to any unit regardless of echelon, type, skill density, mission essential tasks, geographic location or mission during peace or war. The methods are:

- Lifecycle
- Cyclic Regeneration
- Package & Individual Replacements

Collectively, the unit manning system merges the flexibility of individual replacements with unit-centric methods for building and sustaining highly cohesive combat teams over time. By design, the system will stabilize combat units setting conditions for soldiers to establish trust relationships and bond together as a team leading to higher levels of performance and readiness.

3.1 Lifecycle Unit Manning

Under lifecycle manning, leaders and soldiers assemble, train and employ as a team. Lifecycle unit manning is the preferred method for building combat teams. It is well suited to reconstituting a unit that experiences 50%, or more, turnover; whether replacing programmed transfers or un-programmed casualties. Lifecycle manning consists of four phases: build, train, employ and release. Time-wise, the build and release phases are not counted as part of the unit's lifecycle. During the build phase, designated members of the unit's command team accomplish actions that prepare the unit for manning and building a combat team. Depending upon the unit's size, training starts may be staggered at lower-echelons so time and training opportunities are not lost. During the train phase, the unit's focus is on individual and collective training – building unit competency leading to unit certification. The length of time for units to become trained and certified will vary by the type of unit and other factors such as personnel turnover, soldier proficiency, the mission, unit location and echelon. The train phase concludes with certification day (C-day) which formally recognizes that the unit is employable and ready for rotations or deployments. During the employ phase, the unit maintains its certified level of training readiness (T-rate) and continues to work on mission essential tasks while building higher levels of collective team competency. Soldiers bond together through shared experiences. The unit continues to develop vertical and horizontal cohesion among all soldiers. Throughout the employ phase, the unit maintains its capability to accomplish all assigned missions. During the release phase, the unit stands down and is not available for employments. Release day (R-day) marks the end of the employ phase and is similar to organization day described above. The figure below depicts the phases of life cycle unit manning and illustrates the overlap of successive lifecycles.

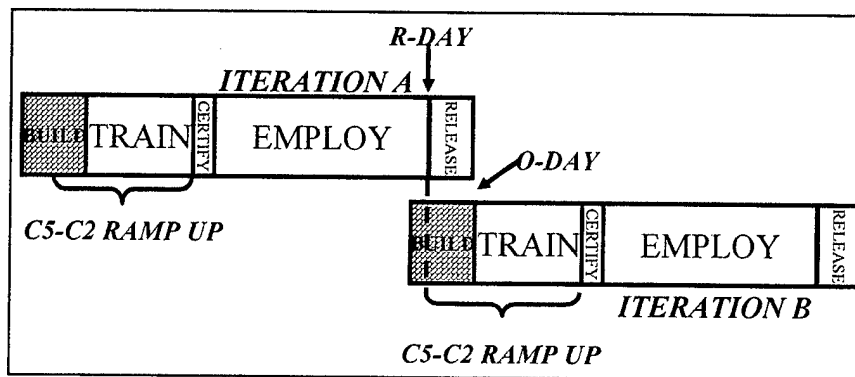


Figure 3.1 Lifecycle Unit Manning

3.2 Cyclic Regeneration

As discussed previously, personnel turnover under the individual replacement system generates unit turbulence that breaks down team unity. Cyclic regeneration manning rigorously manages personnel losses and gains to preserve team cohesion. This enables the team to continue to function smoothly at a high level of effectiveness. Cyclic regeneration is ideally suited for enabling units to recover from losses in the 10 to 30% range where an experienced cadre of veteran soldiers are available to quickly integrate new soldiers into a combat team and conduct individual and collective training. This approach quickly reestablishes the team while preserving mission capability of the unit. The unit remains continuously ready and, if needed, employable even during regeneration.

As shown in the figure below, cyclic regeneration consists of two phases: regeneration and employ. Programmed losses and gains are compressed into the regeneration phase which allows the command team to focus exclusively on in-processing and training new soldiers and out-processing departing soldiers and families. The time between unit regenerations may range between 8 to 14 months depending on the mission and operational requirements.

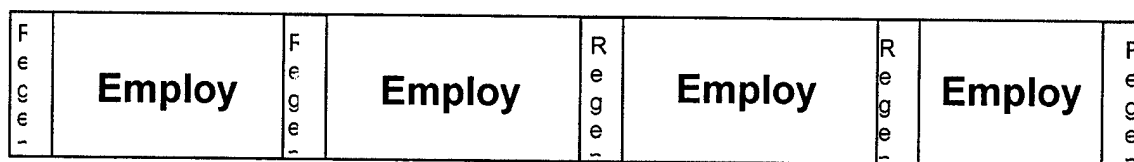


Figure 3.2 Cyclic Regeneration Unit Manning

3.3 Package and Individual Replacements

Package and individual replacements provide a quick and effective means to replace programmed and un-programmed losses in key leader positions and low density, mission-critical skills. Generally, package and individual replacements will occur periodically at planned intervals, or upon request to replace losses prior to a major operational event. Individual and

package replacements are also applicable for manning units, or sub-elements of a unit, that must remain functional at all times.

3.4 Applying Unit Manning Methods to Transform the 172nd Infantry Brigade

When 3rd Brigade/2d Infantry, Fort Lewis, Washington transformed into the Army's first Stryker brigade combat team, SBCT1, the unit was fenced according to IRS policy. This was intended to prevent soldiers from departing the unit prior to initial operating capability (IOC) in the summer of 2003. However, policy exceptions allowed many soldiers to depart early for reenlistment or professional development timelines. Fencing failed to stabilize SBCT1 and, as a result, SBCT1 experienced 62% turnover before reaching IOC.

Transformation of the 172nd Infantry Brigade, Fort Wainwright, Alaska, into SBCT3 started in October 2003 and will continue through the summer of 2005. Equipment turn-in and leader training began in June 2003. In February 2003, the Secretary of the Army, The Honorable Tomas E. White, and the Chief of Staff, Army, General Eric Shinseki, directed the Unit Manning Task Force develop a unit manning plan for the 172nd Brigade, in part to avoid problems associated with manning SBCT1.

The remote location of the Alaska Command, coupled with the extreme Alaska environment, imposed constraints and conditions on unit manning that may not exist for any other unit. Analysis of Alaska's constrained transportation, storage and human resources, plus a very tight housing market, made it infeasible to use lifecycle exclusively to unit man SBCT3. To deal with these challenges, the Task Force developed a manning plan for SBCT3, depicted in the figure below, that combined lifecycle and cyclic regeneration.

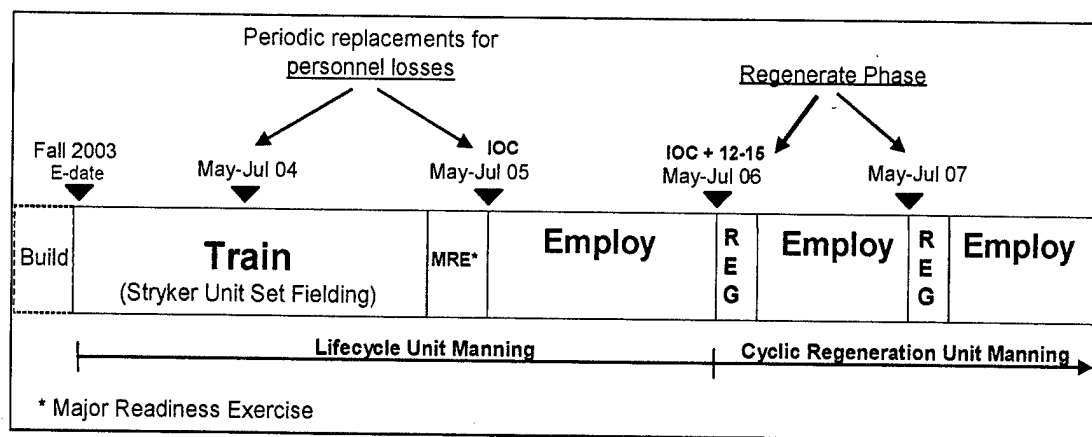


Figure 3.3 172d SIB / SBCT 3 Unit Manning and Transformation

Scheduling Unit Manning in Support of 172nd Transformation

At the highest levels of the Army, scheduling unit manning requires de-conflicting individual-centric professional development policies governing assignments, promotions, schools, and commands from unit-centric initiatives such as Army transformation, force modernization and unit rotations. These changes must then be interpreted and applied at the

unit level, where scheduling involves synchronizing and aligning assignments, training, schools, and development for thousands of soldiers with the unit's transformation timeline. The 172nd transformation timeline, shown below, highlights the complex nature of the unit manning scheduling problem at the unit level.

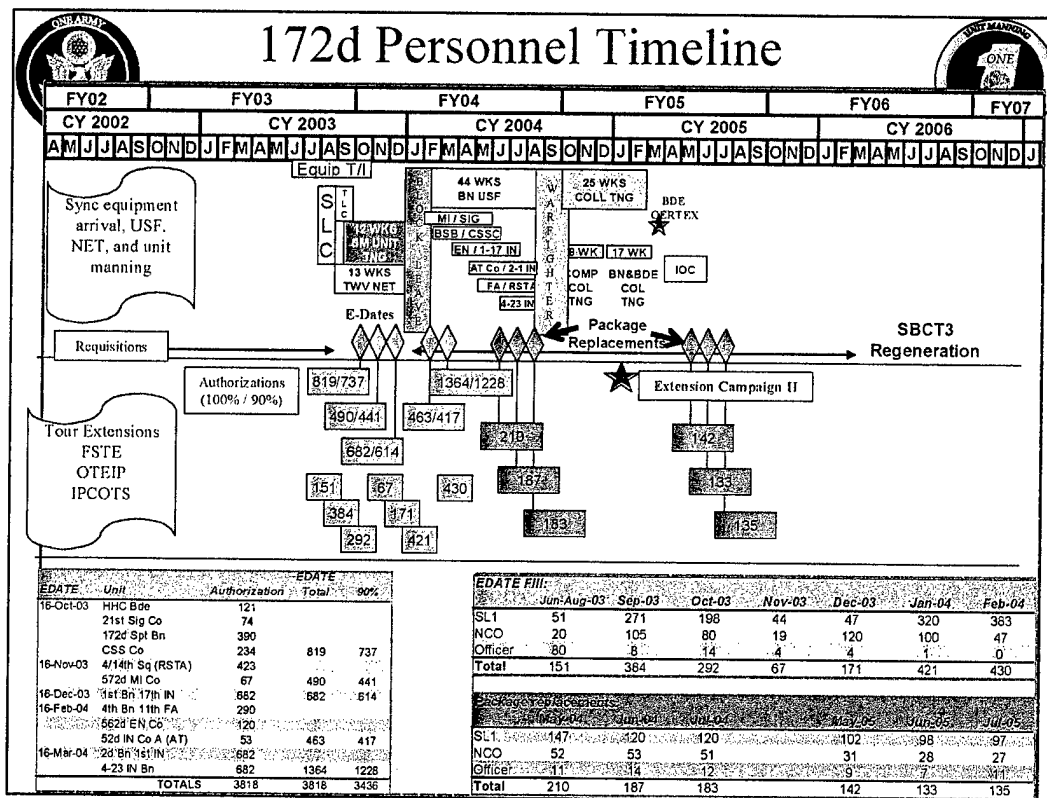


Figure 3.4 172d SIB / SBCT 3 Transformation Schedule

The upper section lays out new equipment fielding, new equipment training and critical transformation-related courses. The middle section gives estimates for personnel replacements and windows, by unit and E-dates, plus package replacements for 2004 and 2005. The tables at the bottom estimate personnel replacements for high density and critical positions.

Unit manning rescheduled command tours to fit the transformation timeline. Since commanders were already slated for SBCT3, the Task Force developed a plan to merge timelines for current and subsequent commanders with transformation requirements through 2007.

The Task Force also recommended policies, guidelines and rules for managing external and internal unit turbulence. External turbulence refers to personnel moves into or out of the unit-under-consideration. Internal turbulence involves personnel moves within the unit-under-consideration and will be managed by the command team. While each instance of internal turbulence creates churn, internal moves create less friction and impact upon unit cohesion than external moves. In making internal moves within and between sub-units, command teams must consider both professional development needs of soldiers and what is best for mission accomplishment. The figure below lists guidelines for managing internal personnel actions that the Task Force recommended remain under the control of the SBCT3 commander.

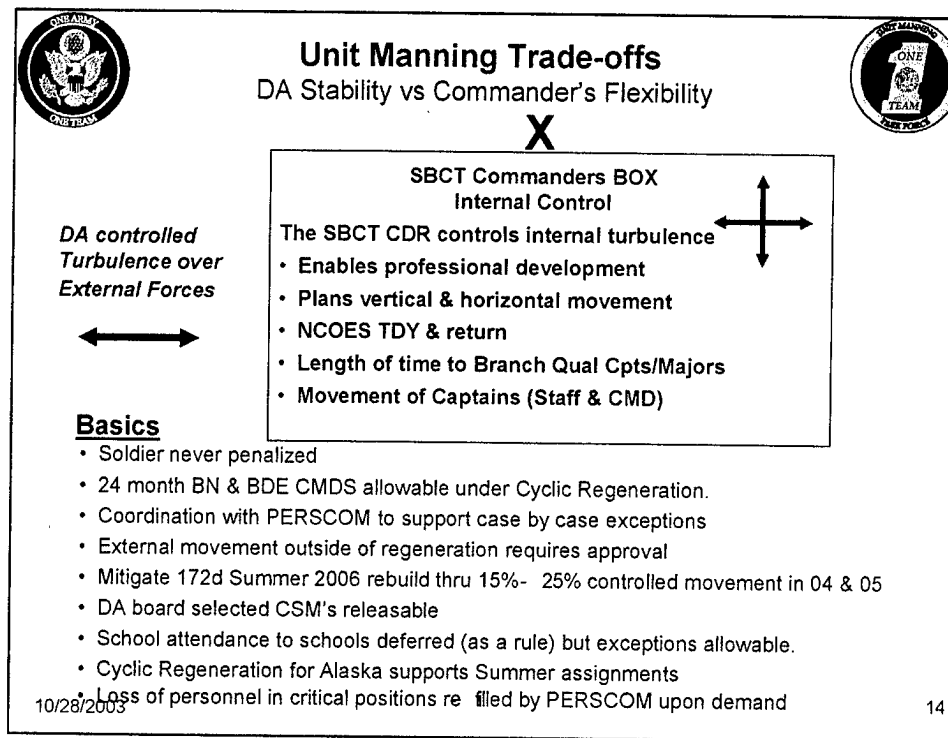


Figure 3.6 Personnel Turbulence

To summarize, lifecycle is designed to efficiently build, or rebuild, units when personnel turnover exceeds 50%. Lifecycle sets conditions for building cohesive, high-performing combat team that remain together for the duration of an assigned mission. Lifecycles can range between 18 to 36 months depending on the unit's type, echelon, mission and location. During the train and certification phases, lasting 6 to 24 months, the unit is 'not ready' and unavailable for employment. Cyclic regeneration manages unit turnover of 10 to 30% into a compressed regeneration period lasting 30 to 120 days. During this time, the unit remains continuously ready for employment if needed. The adaptability of cyclic regeneration makes it well suited for sustaining units when infrastructure or environmental constraints restrict large-scale personnel turnover or operational requirements necessitate the unit remain 'ready' at all times. Package and individual replacements can be used to maintain unit personnel readiness by replacing losses in critical positions and low density skills as they occur, subject to personnel availability and needs of the Army elsewhere. When used together, lifecycle, cyclic regeneration, and package and individual replacements provide the Army with a flexible, tailorable, unit-centric manning system for meeting the operational needs of any unit in the Army and for the purposes listed below:

- Quickly and efficiently build combat units and combat power;
- rapidly regenerate combat units to ready them for future operations;
- support Army transformation by manning units for the duration of the transformation lifecycle – from unit set fielding through employment;
- man units for the lifecycle of a scheduled rotation or operational deployment; and
- Sustain committed units while in operational environments through either cyclic regeneration or by individual or package replacements.

4. Model Formulation

Formulation of a mathematical model of the unit manning problem, and development of a unit manning scheduling system, incorporates strategic Army initiatives such as unit rotations, transformation of separate brigades into brigade combat teams, and force modernization. The Task Force recommended to senior Army leaders that force modernization be synchronized with unit manning by nesting modernization in lifecycle or regeneration manning to reduce unit turbulence. Although not approved yet, the model reflects this recommendation. The model must also account for real-world conditions and rules reflecting Army processes such as accessions, initial entry training, professional development programs involving formal training, military education, and assignment policies and practices. Before presenting the model, factors essential to both mathematical formulation of the problem and model development are discussed.

4.1 Dynamics of the Unit Manning Scheduling Problem

Dynamics of Unit Manning in Support of Brigade Transformation and Unit Rotations

Time variability associated with unit manning, unit rotations and transformation affects scheduling. Unit rotations normally last 6 to 12 months but may run longer depending upon operational requirements. As the Army becomes more proficient at transformation, timelines will shorten. For example, SBCT1 transformed in approximately 33 months while SBCT2 took approximately 27 months. Conversion of SBCT3, as planned, will last approximately 22 months.

Lifecycle Dynamics

- Lifecycle unit manning consists of four phases: build, train, employ and release. Time-wise, the build and release phases do not affect the unit's lifecycle. Depending upon the unit's echelon, type and mission, the duration of a lifecycle may vary 18 to 36 months.
- The length of time for units to become trained and certified will vary by the unit's type and echelon, personnel turnover, soldier proficiency, mission and unit location. Task analysis of transforming and non-transforming units shows unit non-availability will range between 12 to 24 months and 6 to 12 months, respectively.
- The employ phase will normally run 12 to 24 months. Rotations and deployments are nested inside employment windows. Rotations and deployments completed prior to the end of the employ phase may present a second employment opportunity (time permitting) or cut short the current employ phase triggering the start of the next unit manning cycle.

Cyclic Regeneration Dynamics

- Cyclic regeneration consists of two phases: regeneration and employ. Based on historical turnover, analysis suggests that a full cycle of cyclic regeneration manning last 12 to 24 months.

- Programmed losses and gains are compressed into the regeneration phase. The length of unit regeneration may last 1 to 6 months but would normally be completed in 2 to 4 months.
- The time between unit regenerations varies between 8 to 14 months depending on the mission and operational requirements.
- The duration of regeneration will depend upon the unit's type, location, echelon and percent turnover. Although units remain continuously ready during regeneration, employing a unit prior to completion of regeneration will undoubtedly lower unit effectiveness.

Dynamics of Forecasting Unit Availability and Feasibility Criteria

Combat brigade availability, the number of combat brigades available each month to meet operational requirements is constrained below at 10; a soft constraint established by Headquarters, Department of the Army (HQDA) for military response considerations. Availability is bounded above by current force structure at 33 brigades. Determining availability of brigades for unit manning in some month t requires the following information:

1. Number of combat brigades that become available in month t having just completed an employment in month $t-1$;
2. number of combat brigades employable but not committed in month $t-1$ that are again available at the beginning of month t to meet operational requirements; and
3. number of brigades scheduled for rotation and transformation requirements, and the forecasted duration of each event.

The number of brigades available in month t is impacted by past unit manning decisions. For example, if unit manning decisions made prior to month t reduce brigade availability in month t , or if availability drops below the soft lower bound, then more brigades started unit manning in previous months than what might have or should have, respectively. In any month, it is possible for previous unit manning decisions to result in a brigade availability shortfall where the number of brigades is not sufficient to meet demand; i.e., the number of brigades available falls below HQDA's soft lower bound. When this occurs, the schedule is said to be infeasible. In such cases, previous unit manning decisions can be sequentially revised to (possibly) correct the brigade shortfall thereby generating a feasible unit manning schedule. Brigade availability can be affected by either (1) the unit manning method used (lifecycle or regeneration); or (2) a decision to employ a brigade in a given month for a specified, yet alterable, period of time.

Dynamics of Compressing the Unit Manning Cycle

In some cases, it may be possible to eliminate a brigade shortfall by changing the unit manning method or by compressing phases within the unit manning cycle. For example, compressing previously scheduled lifecycles will make brigades available sooner. This can be accomplished by (1) shortening training, regeneration or employment phases; (2) reducing or

eliminating breaks or block leaves between unit manning phases or manning cycles; or (3) a combination of options. However, the practice of compressing the cycle can negatively impact training readiness, morale and unit performance as explained below

One way to compress the cycle by one to two months is to reduce or eliminate breaks and block leaves between unit manning phases or manning cycles. Training, by design, is always challenging and, at times, highly stressful. The Army's training process is intended to develop soldier skills and build team confidence through competency at successfully accomplishing demanding tasks. Through tough, demanding training, soldiers acquire mutual confidence, respect and trust. Continuous weeks and months of training are, in many ways, as stressful for veteran soldiers as for new recruits. Cadre and recruits will typically train 12 to 15 hours a day leaving little time for families and personal affairs. Compressing the cycle will likely hurt morale and decrease unit effectiveness working against the goal of building cohesion and high performance. Therefore, it should only be used when absolutely necessary.

Backlogging

It is conceivable that real world threats to either national security or interests abroad could demand a response that exceeds the 33 active duty combat brigades currently in the force structure. This results in a situation called backlogging. In the context of this study, backlogging implies that the threat will not be responded to until brigades become available. In reality, however, such an occurrence would trigger a call-up of National Guard and reserve forces to respond to the situation. Since threats to national security and national interests will not go unchallenged, backlogging is not included in model formulation.

Estimating Availability of New Recruits to Support Unit Manning

This study assumes an Army force structure of 33 combat brigades. Lower enlisted soldiers in grades E1 through E4, referred to as Skill Level 1, comprise approximately 60% of brigade strength. Maintaining the personnel readiness of these units generates demand for new recruits. Before being eligible for an operational assignment, new recruits must complete initial entry training.

Schedule feasibility depends upon the availability of Skill Level 1 soldiers to meet unit manning requirements, subject to demand for Skill Level 1 soldiers throughout the rest of the Army. For the scheduling problem presented here, recruit availability is estimated ahead of time for each month t and year j of planning horizon T_j , given annual recruiting targets R_j for each year j . The absence of a random disturbance makes forecasting the availability of new recruits completely deterministic. The figure below illustrates the percent of annual recruit arrivals by month. Year-round recruiting focuses primarily on graduating high school students.

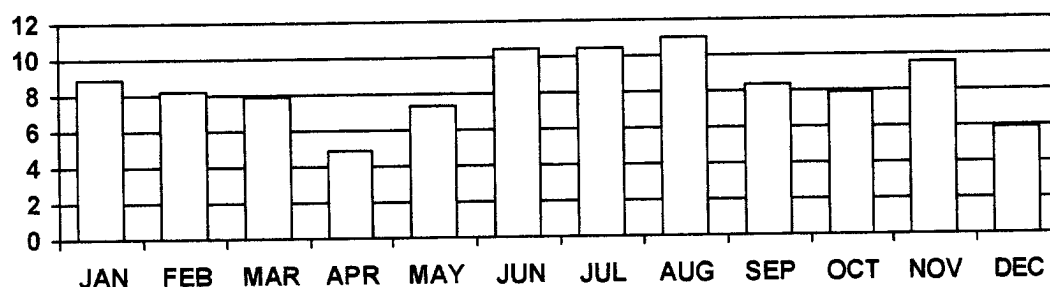


Figure 3.7 Percent of Annual Recruit Arrivals by Month

This pool of recruits causes basic training to surge somewhat during summer months. A modest surge also occurs around Thanksgiving and Christmas due to a break in training during the holidays. Historical recruit training data was provided by the Mr Doug Hetler of the U.S. Army Training and Doctrine Command Headquarters.

Unit Manning Scheduling Horizon and Event Scheduling

As a practical consideration, events such as unit manning in support of rotations and transformation will be scheduled as if they start and end on the first and last days of a month, respectively. When one event ends (on the last day of month t), the next scheduled event will start immediately (on the first day of month $t+1$). These assumptions simplify scheduling events over the 164 month planning horizon.

Metrics for Evaluating Unit Manning Feasibility

In January 2003, the Army Deputy G3 for Operations, Major General James Lovelace, and Unit Manning Task Force Director, Colonel Mike McGinnis, briefed Chief of the Army Staff, General Eric Shinseki on the status of unit manning and unit rotations. During the update, the Chief directed the Task Force to:

- analyze the feasibility of unit manning the Army's combat brigades; and
- identify and analyze Army-level 'friction points' related to transitioning the Army from an individual replacement system to a unit manning system.

The ratio of brigades available to total brigades in each planning period serves as the primary objective in the formulation of the scheduling model presented below. The heuristic scheduling methods make use of the brigade availability ratio as a readiness performance measure for evaluating the feasibility of unit manning schedules. Other measures used to evaluate the feasibility and acceptability of unit manning included cost, cumulative readiness as measured by availability of brigades over the 164 month planning horizon, and demand and utilization of high density Skill Level 1 soldiers.

4.2 Related Work

A literature survey did not disclose papers directly related to the unit manning scheduling problem. However, the literature review did locate two somewhat related resource scheduling problems that suggested ways to model the unit manning scheduling problem. Yang and Ignizio (1987) solved a military training resource scheduling problem that dealt with scheduling training resources and activities for US Army battalions at an initial entry training installation. In formulating their problem, the authors used a heuristic program applied in two phases to schedule training activities and resources. McGinnis and Fernandez (1994) modeled the U.S. Army basic combat training phase of initial entry training. Their problem was to schedule hundreds of training companies to support initial entry training, where training company scheduling also involves deciding (1) how many recruits to assign to training companies each week; and (2) how long each manning cycle should last.

4.3 Mathematical Formulation of the Scheduling Model

Key Modeling Assumptions

- Finite scheduling horizon of T_j equal periods
- The objective of this study is to demonstrate the feasibility of unit manning (UM) all 33 combat brigades, and sustaining unit manned brigades over the 164 month planning horizon. Unit manning is applied in conjunction with two scheduled 'events': rotations and transformation.
- Force modernization is synchronized with unit manning to eliminate out-of-cycle turbulence;
- Varying but bounded brigade manning lifecycle lengths for transformation and rotations.
- Varying but bounded cyclic regeneration manning.
- No backlogging of units to be manned, or equivalently, no backlogging of the requirement for unit manning.
- No backlogging of demand for brigades to meet national security requirements.
- No change to the number of brigades in the Army force structure.

Mathematical Notation

j : Year of the planning horizon, $j \in \{1, 2, \dots, J\}$.

t : Month of year j , $t \in \{1, 2, \dots, T_j\}$ where T_j denotes the last month of year j .

B_j : Total number of brigades to start events in year j .

$B^*(t_j)$: Balance of brigades to start an event in year j as of month t in year j .

$b_{L,C}(t_j)$: Number of brigades to start an event in month t of year j where subscripts L and C denote lifecycle (L) and cyclic regeneration (C) manning, respectively, for the event, \bar{B} and \underline{b} denote upper and lower bound for brigades.

$I(t_j)$: Number of idle brigades at the beginning of month t in year j .

- $x_R(t_j)$: Length of lifecycle manning–unit rotation (UM–UR) lifecycle, in months, that starts in month t of year j . Subscript R denotes lifecycle manning in support of a rotation. \bar{X}_R and \underline{x}_R denote the upper and lower bounds, respectively, for the duration of a UM–UR lifecycle.
- $x_A(t_j)$: Length of unit manning–Army transformation (UM–AT) lifecycle, in months, that starts in month t of year j . Subscript A denotes lifecycle manning in support of transformation. \bar{X}_A and \underline{x}_A denote the upper and lower bounds, respectively, for the duration of a UM–AT lifecycle.
- $y(t_j)$: Length of cyclic regeneration manning (i.e., regeneration and employ phases) that starts in month t of year j . \bar{Y} and \underline{y} denote upper and lower bounds for the length, in months, of cyclic regeneration manning.
- R_j : Annual Army recruiting objective for year j determined by HQDA.
- $r(t_j)$: Estimated number of recruits available for unit manning in month t of year j .
- $p(t)$: Frequency distribution of new recruits who complete initial entry training in month t of any year.
- $\delta(t)$: Recruit availability rate for unit manning in month t where $0 \leq \delta(t) \leq 1$.
- S_L : Skill Level 1 soldiers required for lifecycle manning (L) one brigade.
- S_C : Skill Level 1 soldiers required for cyclic regeneration manning (C) one brigade.

Modeling Constraints

$$\bar{X}_R \geq x_R(t_j) \geq \underline{x}_R : \quad \text{Lifecycle manning–unit rotation constraint} \quad (1)$$

$$\bar{X}_A \geq x_A(t_j) \geq \underline{x}_A : \quad \text{Lifecycle manning–unit transformation constraint} \quad (2)$$

$$\bar{Y} \geq y(t_j) \geq \underline{y} : \quad \text{Cyclic regeneration manning constraint;} \quad (3)$$

$$\bar{B} \geq B_j : \quad \text{Scenario feasibility constraint;} \quad (4)$$

$$b(t_j) \geq 0 \quad \forall (t, j) : \quad \text{Backlogging constraint;} \quad (5)$$

$$\bar{B} \geq I(t_j) \geq b(t_j) \quad \forall (t, j) : \quad \text{Brigade feasibility constraint.} \quad (6)$$

$$S_L b_L(t_j) + S_C b_C(t_j) \geq r(t_j) : \quad \text{Recruit feasibility constraint.} \quad (7)$$

Modeling Relationships and Equations

The number of brigades remaining to start an event in year j as of month t of year j is

$$B^*(t_j) = B_j - \sum_{i=1}^t b(i_j), \quad (8)$$

$$\text{where } B_j = \sum_{t=1}^{T_j} b(t_j). \quad (9)$$

The number of brigades that become available in month t having completed a unit manning cycle that began $l \in L$ months earlier is

$$\sum_{l \in L} b(t_j - l). \quad (10)$$

The possible values for l , in months are given by the set

$$L \in \{x_A(t_i = 24, 30, 36), x_R(t_i = 18, 24, 30), y(t_i = 12, 24)\}, \text{ where} \quad (11)$$

the model determines the number of brigades that become available in month t by enumerating, for each $l \in L$, $b(t_j - l)$ and the values of $x_R(t_j)$, $x_A(t_j)$ and $y(t_j)$.

A balance equation accounts for the number of 'idle' brigades carried forward from month t to month $t+1$ of year j to meet demand for brigades. An idle brigade is one that is available but not employed; that is, the unit is neither a rotational unit nor employed to meet an un-programmed operational requirement. Idle brigades represent unit manning candidates available to start manning at the beginning of a month. The balance equation for idle brigades is given by

$$I(t_j + 1) = I(t_j) + \sum_{l \in L} b(t_j - l) - b(t_j). \quad (12)$$

The number of brigades 'idle' at the end of a month is always carried forward to the next month. $\sum_{l \in L} b(t_j - l)$, $l \in L$, represents the number of brigades that are busy in month $t-1$. The model determines the number of 'busy' brigades in month t by counting backwards in time from t to $t - l + 1$, where l in month t represents the manning cycle length decision l from the set $L \in \{x_A(t_i), x_R(t_i), y(t_i)\}$.

An index of 'readiness' based on unit availability, the ratio of idle brigades in month t of year j to total brigades, is computed for each scheduling period:

$$g[t, b(t_j)] = \frac{I(t_j)}{B}. \quad (13)$$

Cumulative 'readiness' based on the summation of (13) over the planning horizon, serves as an index for comparing the quality of unit manning schedules generated using the heuristic methods presented in Chapter 5 against units manned under IRS:

$$J = \sum_{t=1}^{T_j-1} \frac{I(t_j)}{B}. \quad (14)$$

The expected number of recruits available for unit manning in month t of year j is

$$r(t_j) = \delta(t)p(t)R_j. \quad (15)$$

The Army recruiting objective R_j is assumed to be greater than or equal to the number of new soldiers required to meet the needs of the Army in a given year j .

The following variables and parameters are integer:

$$\{I(t_j), x_A(t_j), x_R(t_j), y(t_j), b(t_j), B^*(t_j), B_j, r(t_j)\}.$$

5. Unit Manning Scheduling System and Results

5.1 Model Objectives and Metrics

The unit manning scheduling model was developed to analyze the feasibility of unit manning in support of (1) the Army's transition from a forward deployed force to an expeditionary, rotational-based Army in support of the post-Operation Iraqi Freedom Posture of Engagement (POE); and (2) transformation of brigades into Stryker brigade combat teams and Units of Action as the Army transitions to the Objective Force. The Task Force was directed by the Secretary of the Army and the Army Chief of Staff to (1) determine the feasibility of unit manning the Army's 33 combat brigades in support of unit rotations and transformation; and (2) identify and analyze frictions in transitioning Army combat brigades from an individual to unit manning system.

Metrics used for this analysis included the following:

- By month, the expected number of brigades (1) available for contingency operations; (2) on rotation or committed to an operational deployment; (3) unavailable due to undergoing lifecycle or cyclic regeneration unit manning; or (4) unavailable due to undergoing transformation.
- Forecasted Skill Level 1 personnel requirements for high density skills (i.e., infantry, armor, and cavalry) generated by both IRS and unit manning methods.
- Estimate the 'pace of change' for transitioning to a unit manning system.

- Estimate the number of brigades to start lifecycle and cyclic regeneration unit manning each month.

5.2 Solution Methods

Integer Programming Approach

The first attempt to solve the unit manning problem used an integer program (IP). The IP scheduled the Army's 33 combat brigades at the brigade level. As a result, an entire brigade combat team, consisting of three combat maneuver battalions and two support battalions, was scheduled to begin unit manning at the same time. Over the 164 month planning horizon, this distorted the number of units categorized as 'unavailable' leading to significantly lower readiness compared to unit manning using individual replacements.

The integer program was modified to schedule combat battalions to address the readiness problem discussed above. Programming variables were the number of battalions (95), unit type (8), manning phases for lifecycle and cyclic regeneration, and monthly scheduling periods for the planning horizon (164). The decisions to make in each period were (1) the number of units to man each period; and (2) the type of unit. Chapter 4, *Model Formulation*, gives other constraints included in the formulation. Instantiation of the integer program for 95 battalions generated 996 integer decision variables and 10,800 constraints. Programmed in an algebraic programming solver called GAMS, the model took several days of CPU time, running continuously on a fast desktop computer, to find a feasible solution; unacceptable for quick-turn-around 'what-if' analysis. As formulated, the integer programming solver was not well suited to handling the temporal aspects of the large scale scheduling problem and the extended planning horizon that characterize the unit manning problem. Although other solvers, or a more efficient, effective formulation of the unit manning problem could have been attempted, tight timelines and limited resources precluded pursuing these approaches.

Heuristic Method

An alternative approach was a heuristic solution procedure. The heuristic approach presented here is applied sequentially in two phases. The heuristics were implemented in a spreadsheet-based decision support system well suited for quickly generating *feasible* unit manning schedules. The modeling environment allows users to easily make changes to input parameters and view the effects of the changes to the unit manning schedule and related friction points.

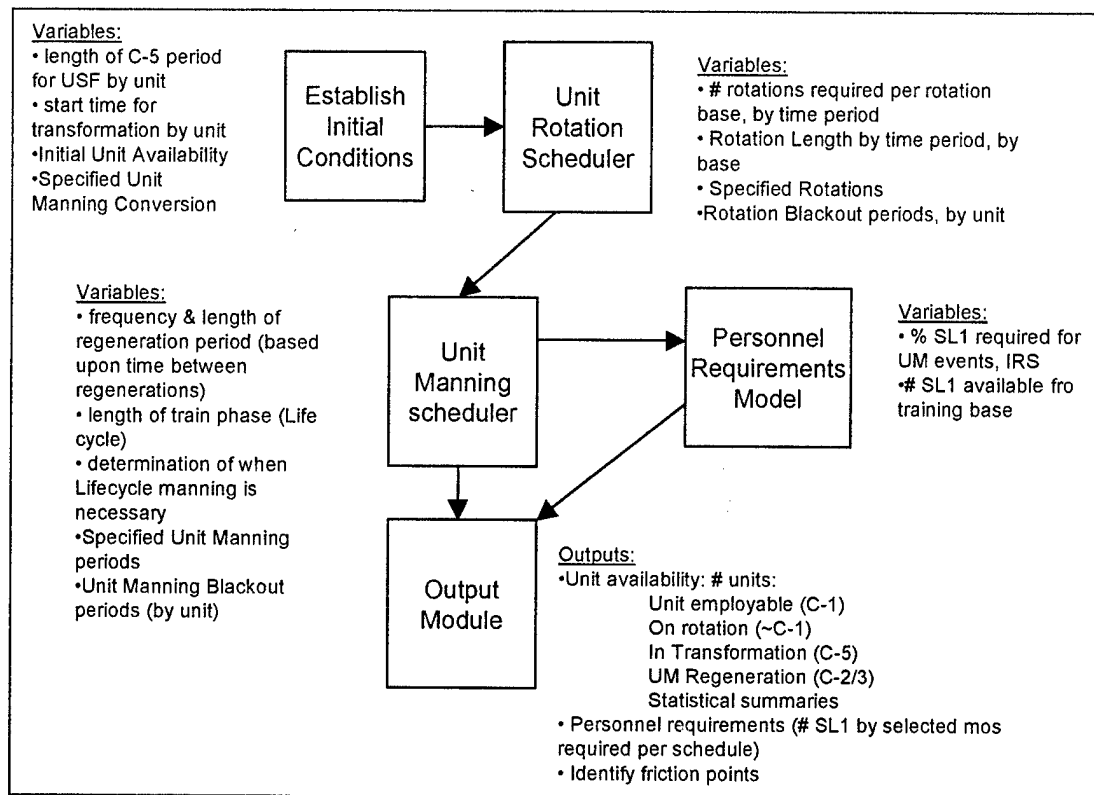
The two-phased heuristic approach makes successive passes over the planning horizon to generate a unit manning schedule in support of unit rotation and transformation of the Army's 33 brigades. The two phases are:

1. Schedule unit rotations and transformations.
2. Generate a feasible unit manning schedule in support of rotations and unit transformation if one exists.

Scheduling rules and parameters are specified in the model ahead of time by the system user. The heuristic scheduling process determines the 'best' schedule based on the performance measure applied to evaluate competing feasible manning scenarios. In each period, the manning method applied to a unit is the one that best fits the operational requirements of the unit based on information known in the current period, and subject to feasibility criteria for unit manning schedules (see Chapter 4). Following the generation of a unit manning schedule, personnel requirements for unit manning the unit-under-consideration are compared against the availability of Skill Level 1 soldiers, subject to Army-wide requirements.

5.3 Model Inputs and Initial Conditions

Model Inputs: Key model inputs include the variable shown on the illustration below:



Input tables make it easy to build manning scenarios tailored to real-world unit rotation and transformation requirements. The flexibility of the system allows analysts to evaluate the effects of various manning methods on unit availability, over time, for rotations and transformation.

5.4 Model Output and Results

Model output reflects performance measures for evaluating unit manning scenarios to determine the feasibility of unit manning combat brigades, and to analyze key 'points of

friction' generated by transitioning from individual to unit manning. Model output and the interpretation of results provided decision-makers, the Secretary of the Army and the Army Chief of Staff, as well as other stakeholders, such as Assistant and Under Secretaries of the Army, Special Assistants to the Office of the Secretary of Defense and serving and retired three and four star General Officers, with insights and a thorough understanding of the problem. Sound modeling and good analysis were critical to decision-makers forming reasoned judgments and making informed decisions about unit manning. The metrics used for these purposes were:

- Army readiness, $J = \sum_{t=1}^{T_J-1} \frac{I(t_j)}{B}$, measured by cumulative 'unit availability';
- Forecasted Skill Level 1 requirements for high density skills generated under both IRS and unit manning methods compared with soldier availability $r(t_j) = \delta(t)p(t)R_j$;
- The *pace of change* for transitioning brigades from an individual to unit manning.

The unit manning schedule of 33 combat brigades over the 164 month planning horizon is shown below. The schedule proved to be a powerful means of representing major Army initiatives that helped decision makers see and understand the problem and challenges of synchronizing Army initiatives at a high level. The colors depict the status for each unit.

- Blue. The unit is operationally employed on a scheduled rotation, deployed in response to a contingency, or forward deployed in Korea.
- Red. Unit is 'not available' (C-5 readiness status) due to either transformation or unit lifecycle rebuild.
- Gold. Unit is in a 'ready' status but not finished with unit manning regeneration or lifecycle training phase in support of a scheduled rotation or transformation.
- Green. Unit is available for employment but not deployed.

Projected return of units from ROK

Units returning from current operational assignments

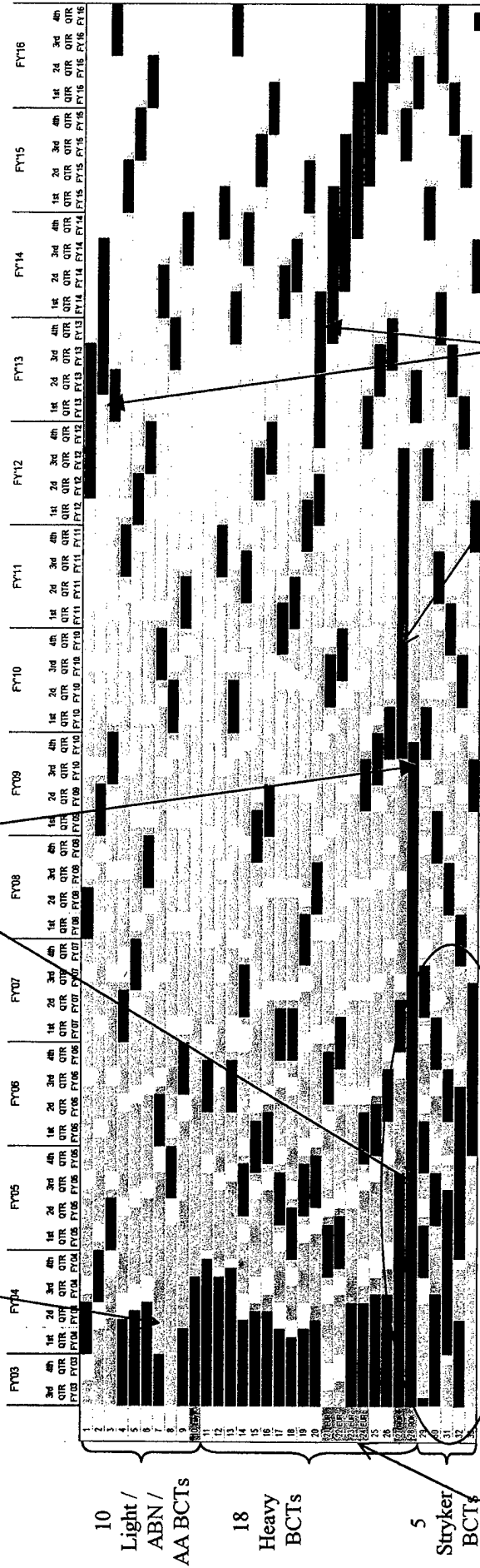
Transformation to UA

SBCT Transformation

Unit stationed overseas highlighted

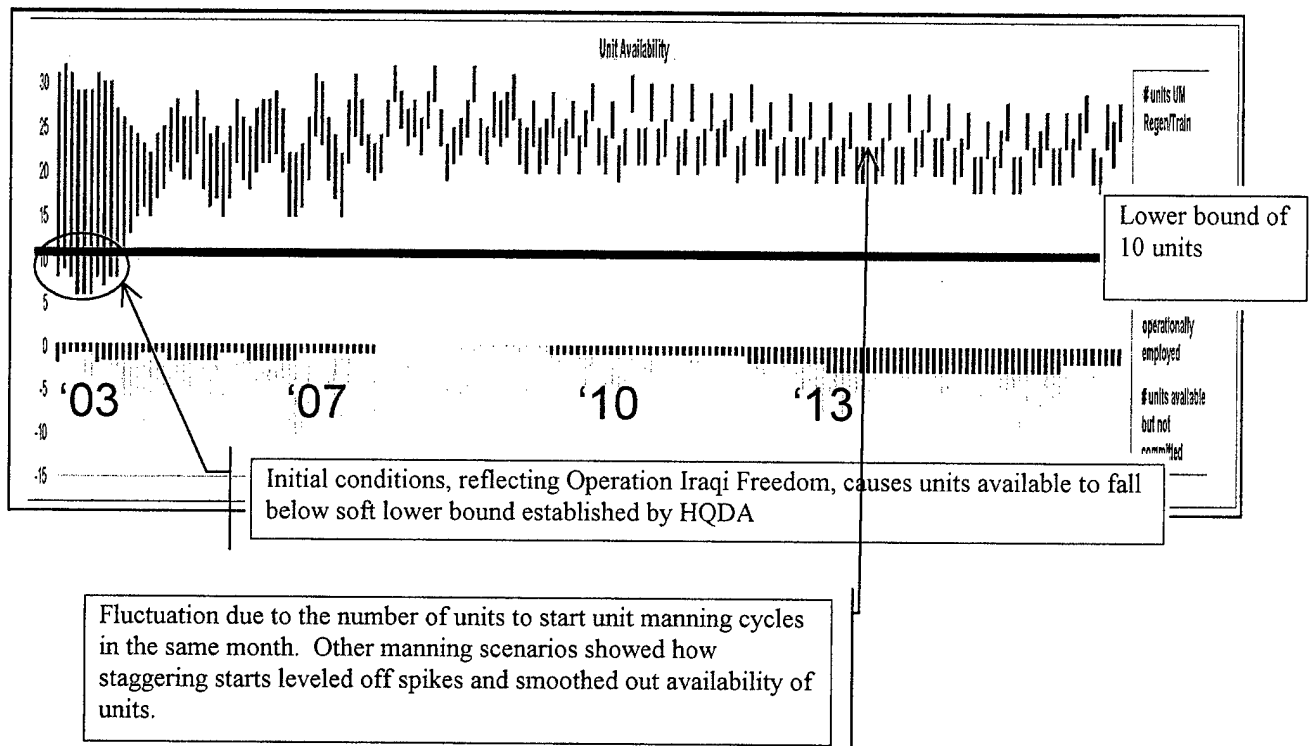
	Available but not committed	UM Regeneration
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Rotating Units	Transforming Units
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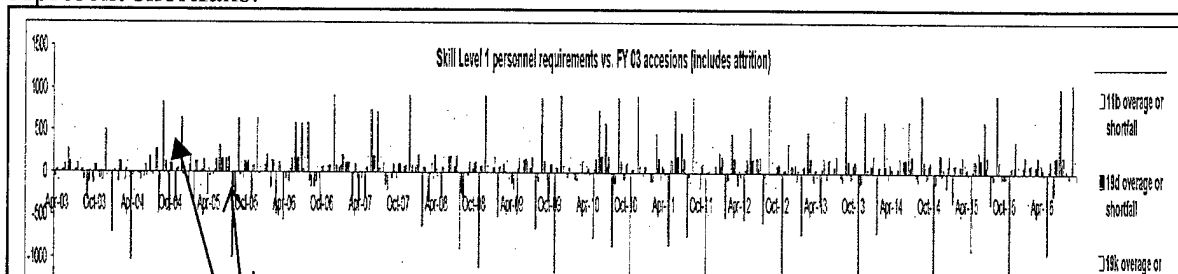
Analysis of Friction Points

The first of friction points is unit availability depicted month by month. The graph shows the number of brigade combat teams available for contingency operations, on rotation, engaged in a deployment, or in some phase of unit manning for rotations or transformation. The solid line across the graph represents the lower bound established by HQDA for meeting national readiness requirements based maintaining unit availability.



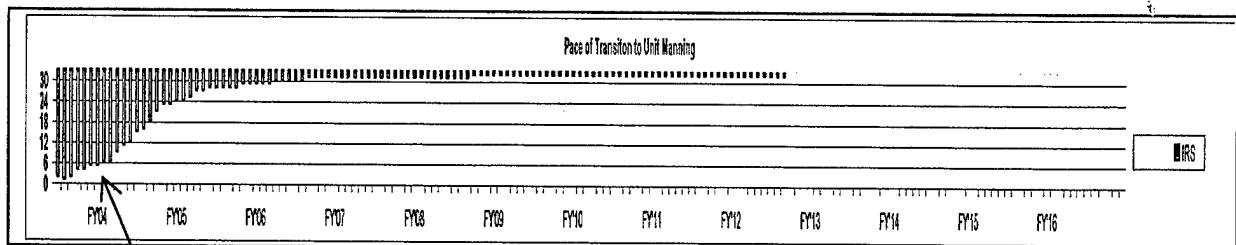
The next performance measure shows *personnel availability* to meet unit manning requirements. Model output allowed the Task Force to assess the ability of the U.S. Army initial entry training program to meet unit manning requirements throughout the scheduling horizon while also meeting demand for soldiers throughout the rest of the Army.

The objective of the analysis was to determine if the training base could support unit manning which could require several thousand soldiers per month depending upon how many brigades undergo unit manning. The figure below is an illustrative scenario showing how the model compares Skill Level 1 soldier availability from the training base to Army-wide soldier demand including unit manning requirements. In any month, values above zero represent more soldiers available than needed while values below zero represent shortfalls.



The model depicts shortages and overages which, once identified can lead to adjustments in accessions and school dates. In this manner The model can be used to help personnel managers improve resource utilization throughout the army by better aligning manning requirements and initial entry training.

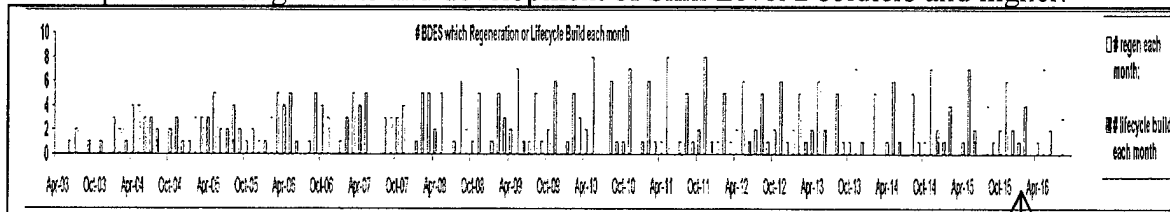
This figure below shows the month by month *Pace of Transition to Unit Manning* based on the number of brigades that remain IRS-manned versus others that convert to unit manning. This is important for several reasons. Unit manning represents a key enabler for a critical Army paradigm shift from *alert-train-deploy* to *train-alert-deploy* and a cultural shift for the Army from *individual-centric* assignments to *unit-centric* team building. The pace of transition must account for the impact that this initiative will have on the Army as an institution. Visibility of the pace of change is also important to institutionalizing key policy changes critical to the success of unit manning.



Graph denotes the pace of change as a function of IRS-manned unit IRS units

This chart below shows the *Number of Regenerations and Lifecycle 'Builds' per Month*. This metric is important because it helps the Human Resources Command better

manage Skill Level 1 requirements, addressed earlier, and shows how unit manning will also impacts the assignments and development of Skill Level 2 soldiers and higher.



The model identifies where scheduled unit manning can be shifted to avoid personnel shortfalls. The model allows personnel managers to analyze 'what if' alternatives and to find acceptable unit manning schedules while also investigating trade-offs between lifecycle and cyclic regeneration or shifting events in the scheduling horizon.

6. CONCLUSIONS

On May 1, 2003, the Unit Manning Task Force briefed the Army Chief of Staff, General Eric Shinseki, on unit manning feasibility and analysis of 'friction points'. The briefing was based on modeling and analysis presented in this paper. At the conclusion of the briefing, the Chief decided that the Army would go forward with unit manning; a decision that is being carried out under the new Army Chief of Staff, General Peter Schoomaker. The first unit to be manned would be 172nd Separate Infantry Brigade, Fort Wainwright, Alaska. General Shinseki and the Secretary of the Army, The Honorable Thomas E. White, jointly approved the following news release announcing this decision.

FOR IMMEDIATE RELEASE

ARMY ANNOUNCES SBCT UNIT MANNING INITIATIVE

The Army announced today that Stryker Brigade Combat Team (SBCT) Three, presently the 172d Separate Infantry Brigade, U.S. Army Alaska, will be the first Army unit manned under the Unit Manning Initiative. The Army's intent for unit manning is to improve combat readiness and cohesion while setting conditions for improved soldier and family well-being. Unit manning synchronizes the assignment of soldiers with the life cycle of their unit. This decision combines two crucial initiatives: first, transforming the Army from an individual soldier replacement system to a unit manning system that enhances cohesion, keeps trained soldiers, leaders and commanders together longer, thereby improving warfighting capability, and second, maximizing the capabilities of Army units.

Unit manning the 172d SBCT will provide the Army with an important opportunity to develop and implement evolving personnel policies tailored to both building and regenerating SBCTs. Army G-1 personnel policy officials have identified a number of personnel policies that could be improved to support unit manning and to decrease personnel turbulence. From this experience, the Army will also gain important insights for unit manning Objective Force units in support of the Army's Transformation Campaign Plan. Unit manning will enable the Army to convert current units into Objective Force units in conjunction with fielding of Future Combat Systems (FCS). The goal is a trained and ready Alaska SBCT deployable for operations from the time of its initial operating capability (IOC) in summer, 2005 and beyond.

"We are an Army at war and transforming. We must transform to be fully ready to fight and win against emerging threats and across the full spectrum of conflict. Unit manning is a part of that transformation and the Stryker Brigade Combat Teams, beginning with the 172nd, are the right units for this initiative," said Secretary of the Army Thomas White.

For more information call Army Public Affairs at 703-697-5343. - END

This paper formulates and models a complex scheduling problem of practical interest to the United States Army; namely, scheduling unit manning in support of unit rotations and Army transformation over an extended finite planning horizon of 164 months. Modeling and analysis in support of the Unit Manning Initiative made several contributions to military operations research and to the United States Army.

- This effort documented, for the Army and the military operations research community, the mathematical formulation of the unit manning scheduling problem that, for the first time, incorporates important dynamics of unit rotations and Army transformation.
- The process of developing the scheduling model brought together disparate groups from Headquarters, Department of the Army Staff including Personnel (G1), Operations (G3), Transformation (G7), Requirements (G8), U.S. Army Human Resources Command (HRC), U.S. Army Training and Doctrine Command, U.S. Army Accessions Command, Objective Force Task Force, Personnel Transformation Task Force (PTTF). Model development created an opportunity for these organizations to work collaboratively on Army initiatives that ultimately moved the Army forward toward transformation and unit rotations.
- Model development resulted in the implementation of an automated scheduling and decision support system capable of supporting broader analyses of a wider range of scheduling problems related unit manning in support of unit rotations and Army Transformation (see below).
- The unit manning decision by the Secretary of the Army and the Chief of Staff of the Army is a key enabler for the Army to make a major paradigm shift from Alert-Train-Deploy to Train-Alert-Deploy.
- The modeling and analysis of unit manning methods, which convinced decision-makers that it was possible to unit man brigades, set conditions for the Army, and unit leaders, to achieve higher levels of *unit cohesion* forged over time among soldiers who trust and respect each other, and function together as a team under stressful, tough, realistic conditions in training and combat.

The Unit Manning Scheduling Model supports the analyses of a variety of Army installation and training program management issues, such as,

- evaluating the economic impact of different resource utilization policies;
- evaluating unit manning readiness as a function of training capacity and training program throughput for meeting future unit manning requirements;
- forecasting training resource requirements for the initial entry training program;
- improved forecasting of operational and training resource requirements; and
- more efficient resource scheduling;

In summary, sound modeling and analysis of unit manning provided senior Army leaders with confidence that a *unit centric* approach to building unit cohesion and high performance teams was feasible. The analysis of unit manning showed that it would be possible for the Army to synchronize the assignments of large numbers of soldiers with training and employment of (unit-manned) units; reduce unit turbulence by managing personnel gains and losses into a compressed time period; and managing force modernization and force structure changes within the unit manning concept. Without constant turnover, units in the future will be able to train to a higher standard and gain the benefits of cohesion and camaraderie which are now only enjoyed in elite units. Unit manning is the key to setting conditions for the Army to build highly cohesive, combat ready teams at brigade and below—units that bear the major responsibility for closing with and destroying the enemy under the most stressful conditions imaginable.

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